CHAPTER

1

Introduction

The electric power industry in the United States is undergoing fundamental changes—from being an industry dominated by regulated monopolies that own entire electricity systems (vertical integration) to one featuring a mix of competitive electricity generation companies, common-carrier transmission organizations, and regulated distribution companies. Spurred by technological advances and a public policy strategy at the federal and state levels, those changes are transforming both wholesale and retail power markets. At the wholesale level, independent power producers now generate more than 14 percent of the nation's electricity for sale at market-based rates to utility distribution companies.[1] At the retail level, 23 states and the District of Columbia have already passed legislation or issued regulatory orders supporting the ability of customers to choose their electricity suppliers.[2] (See the appendix for a brief summary of the history of electricity market organization in the United States.)

One of the powerful forces driving that transition in market structure has been advances in electricity generation technologies that have reduced the costs of smaller-capacity systems—generally those under 2 megawatts. (*See Box 1 for an explanation of the characteristics of electric power.*) Technologies such as microturbines are available in capacities under 100 kilowatts (roughly the size of an automobile engine). Large-scale power plants (100 megawatts or greater), which are typically used by vertically integrated utilities, no longer have significantly lower costs than smaller plants do. That change has weakened one of the main rationales for maintaining electric power production as a regulated monopoly—namely, that the exclusive franchise was necessary to fully exploit the savings in generation and transmission costs from large-scale, centrally located power plants.

The first entities to take advantage of those cost reductions in a significant way have been certain independent power producers, or businesses that generate electricity primarily to sell to the utilities. Most of those producers use generation units with capacities in excess of 1 megawatt. But the cost reductions extend to even smaller generation units (less than 1 megawatt), many of which are suitable for producing power to serve small businesses, commercial buildings, and homes. That development has added one more dimension to the effort to capture the benefits of competitive markets in the electric power industry—the prospect that local small-scale generation could compete with electric power from large, central power plants.

In contrast to the power supplied by utilities and many of the large independent producers, which is often generated away from population centers and moved over extensive transmission and distribution networks, small customer-owned generators are sited at or near the locations where the electricity is used. Those small generators are often not fully integrated with the utilities'

1. Department of Energy, Energy Information Administration, *Electric Power Annual 2000* (August 2001), Table 1, available at www.eia.doe.gov/cneaf/electricity/epav1/intro.html#tab1.

2. Department of Energy, Energy Information Administration, *Status of State Electricity Industry Restructuring Activity—as of February 2003,* available at www.eia.doe.gov/cneaf/electricity/chg_str/regmap.html. According to Energy Information Administration statistics, retail choice is available to some or all of the customers (or will soon be available) in 17 states and the District of Columbia. In the remaining six states, retail competition has been delayed or suspended.

Box 1.

Electricity Basics

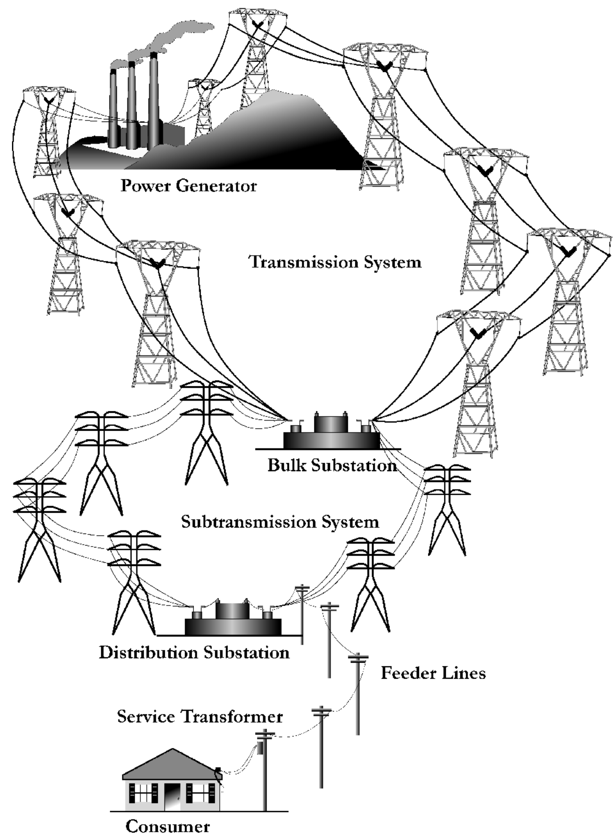
The basic unit of electric power is a watt, which is a rate of producing or consuming energy. A typical lightbulb, for example, consumes electricity at the rate of 75 watts, or 75 watt-hours of electricity in one hour of operation. One kilowatt is 1,000 watts. The average household in the United States uses almost 12,000 kilowatt-hours (12 million watt-hours) per year. A power plant with a 1-megawatt capacity (1,000 kilowatts), operating continuously (8,760 hours) for a year would generate enough electricity to supply approximately 750 households. (A different way to understand what those units of electricity represent is to relate them to horsepower, another measure of power. A kilowatt is roughly equivalent to 1.3 horsepower; a 1-megawatt plant is equal in power to approximately 10 medium-sized automobile engines.)

Another characteristic of electric power is voltage, which is a measure of electromotive force. Electricity is usually generated and transported at very high voltages (more than 100,000 volts). Electric voltage is lowered, by a series of transformers in the substations and on feeder lines close to where it is consumed, until it reaches 120 volts (in the United States) at electrical outlets in a typical household.

In the United States, the electric power system generates a form of electricity, termed alternating current, in which voltage oscillates in a regular cycle. The frequency of that cycle is 60 times per second, referred to as 60 hertz. Electric motors and other devices in the United States are designed to use 60-hertz alternating current. If the electric current deviates significantly from that designed frequency, it can seriously damage motors and appliances.

At any time, the amount of electric power (the number of watts) that is being consumed on a utility network (the system of generation and consumption points connected by wires and other transmission equipment) must be nearly equal to the amount of power that is being generated. The voltage and frequency of the current will adjust according to physical laws to maintain a balance. If a sudden change in consumption occurs without an adjustment in generation (or vice versa),

An Electric Power System



Source: Congressional Budget Office based on a figure from EPRI PEAC Corporation.

the voltage will change, possibly damaging equipment throughout the network. Certain types of generators have controls that automatically adjust output to match consumption. Utility networks also have many protective devices that minimize any damage from a rapid change in voltage. For example, electric fuses or circuit breakers automatically cut off electricity when they detect a large voltage change caused by, say, a lightning strike or short circuit that could damage equipment.

Electricity consumption at any point in time is referred to as the load. On a typical utility network, the load fluctuates continuously as customers start and stop their equipment. Network operators continually adjust

Box 1.

Continued

production to match those fluctuations. When consumption is low, they use plants that are designed to run continuously at a low operating cost. As consumption rises, they add production from other plants—whose operating costs are higher—that are designed to start and stop and adjust output quickly. In periods of extremely high consumption, they use older plants that are less efficient and even more expensive to operate. As a result, the cost of supplying an additional unit of electricity (the marginal cost) typically rises as consumption increases. That cost depends on many factors, including the characteristics of available power plants, the price of fuel, and the location of plants relative to the places where electricity is consumed.

An electric power system has two major functions—generation and transportation *(see the figure at left)*. The United States today has approximately 750,000 megawatts of generating capacity, most of which comes from large commercial power plants with capacities of more than 100 megawatts. Those plants are powered largely by coal or other fossil fuels, although nuclear and hydroelectric power also account for a significant portion of capacity and annual output. In 2000, those plants produced a combined total of 3.8 trillion kilowatt-hours of electricity.

The transportation of electricity is typically broken down into transmission, which is the high-voltage transport of electricity over long distances, and distribution, which is the transport at lower voltages over the last few miles to the point of consumption. No clear line divides the two components, but transmission networks in the United States typically have at least two electric paths between any two points (a loop configuration), whereas the distribution system has a single path between the substation and the consumer (a hub-and-spokes configuration).

electricity networks, which produce power around the clock or on demand from central dispatching stations—although the prospects for fuller integration of such distributed generation with the grid may be desirable.[3]

Policymakers have an interest in the future of distributed generation, not only for the cost savings it can provide to the homes and businesses that produce it but also for the cost savings and additional reliability that it may be able to offer to the entire electricity market. Distributed generation may play a larger role, along with demand-management techniques and further innovations in wholesale and retail markets, in reducing the cost of electricity when traditional supply is tight or market demand is strong. For example, distributed generation may offer retail customers greater flexibility to alter their demand for electricity in response to hourly changes in prices (real-time pricing), thereby promoting the efficient operation and stability of energy markets as they become increasingly competitive. Some observers expect distributed generation to play a role in the commercial development of renewable energy and high-efficiency technologies, adding the associated environmental and safety benefits.

The prospects for distributed generation will be strongly influenced by the outcomes of several policy initiatives. Specifically, the wider adoption of distributed generation and its associated benefits may depend significantly on the structure of deregulated electricity markets, in which the federal government plays a central legislative and regulatory role. Recent legislative proposals considered in the Congress have contained provisions—for example, requirements for nondiscriminatory interconnection with the grid and real-time pricing of electricity—that would directly affect the viability of distributed generation. Also, the federal government has taken an active role in developing and commercializing renewable energy technologies, some of which are well-suited to distributed generation.

This paper analyzes distributed generation by answering four general questions:

- What are the current state of and prospects for distributed generation technologies, particularly in

3. The grid refers generally to a self-contained local or regional network of electric power plants and the high- and low-voltage power lines and transformer stations that deliver the power generated by those plants to customers.

comparison with the conventional supply of electricity? (Chapter 2 addresses that topic.)

- What are the benefits and risks of a wider adoption of distributed generation in a restructured electricity market? (See Chapter 3.)
- What are the barriers to adoption and efficient use of distributed generation technologies? (See Chapter 4.)
- What legislative, regulatory, and administrative initiatives can help lower those barriers while avoiding or limiting the downside risks of greater reliance on distributed generation? (See Chapter 5.)